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Radiation Efficiency Estimation for Spherical Helix Antennas

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The upper bound of the radiation efficiency for the spherical surface antenna have been calculated to find the upper limit for small antennas. This upper bound can be achieved by exciting TE_{10} and TM_{10} mode current. Spherical helix wires can approximate the current distribution on the sphere. However, the radiation efficiency of spherical helix antennas is much smaller than that of the theoretical limit. This difference should be explained by the effect of the difference between surface area of these antennas[1].

In this paper, we obtain the estimation formula for the radiation efficiency of spherical helix antennas. The radiation efficiency of the spherical surface antenna of the radius R can be expressed by[2]

$$\eta \approx \left\{1+\sqrt{\frac{\omega\varepsilon_0}{2\sigma}}\left(\frac{3}{(kR)^4}+\frac{3}{10}\frac{1}{(kR)^2}\right)\right\}^{-1}, \tag{1}$$

where, $\omega, \varepsilon_0, \sigma, k$ are the angular frequency, the permittivity of the free space, the conductivity, the wave number, respectively.

The factor of $(kR)^{-2}$ is replaced by $\pi ka/2$ to represent the dissipated power on the wire of the spherical helix. This replacement results in

$$\eta \approx \left\{1+\sqrt{\frac{\omega\varepsilon_0}{2\sigma}}\frac{6}{\pi ka}\left(\frac{1}{(kR)^2}+\frac{1}{10}\right)\right\}^{-1}, \tag{2}$$

where a is the radius of the wire. The numerical result of Eq. (2) is shown in Fig. 1 and is compared with the case of the spherical helix wire obtained by MoM. These results are slightly different value. However both plot has the same order of $k^{-2.5}$. This result implies that the radiation mechanism of spherical helix antennas may be explained by the radiation from the sphere and the loss energy on the wire.

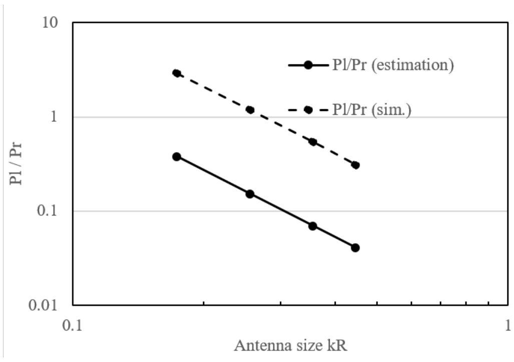

Figure 1. The antenna size vs. the dssipation factor P_l/P_r.

References

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